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GEOLOGICAL INVESTIGATIONS OF QUATERNARY DEFORMATION AND IMPLICATIONS FOR BLIND FAULT ACTIVITY, NORTHERN LOS ANGELES BASIN: COLLABORATIVE RESEARCH WITHGORIAN AND ASSOCIATES, INC. AND UNITED STATES GEOLOGICAL SURVEY

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Technical Abstract – A three-dimensional stratigraphic and structural model was constructed to evaluate Quaternary growth of a complex south-verging monocline that occurs along the northern margin of the Los Angeles basin central trough. The monocline has been proposed be undergoing uplift and folding by active "blind" faulting. Lithologic, paleomagnetic, strontium-isotope ($^{87}Sr/^{86}Sr$), tephra, amino-acid, and faunal data obtained from cored boreholes along the margin of the monocline define five unconformable Quaternary chronostratigraphic units. The oldest unit of the Quaternary sequence rests with angular unconformity on Miocene marine strata along the margin of the monocline and is clearly involved in the fold. This fine-grained unit contains a Repettian and overlying Venturian foraminiferal fauna indicative of upper middle bathyal depths (1500 to 500 m). Normal magnetization and strontium-isotope ($^{87}Sr/^{86}Sr$) data imply that this sequence was deposited during the early Pleistocene Jaramillo geomagnetic chron (~0.986-1.053 Ma). The top of the tilted Jaramillo sequence was truncated, and an on-lapping sequence of chiefly massive (bioturbated) silt and silt loam was deposited that contains the Brunhes-Matuyama magnetic reversal boundary (BM, ~780 ka), and overlying Bishop ash (~760 ka). Deposition of this unit near the self-edge is suggested by its Wheelerian stage foraminiferal fauna (upper bathyal depths, 150 to 500 m) and marine mollusks of shelfal aspect (water depth 50 to 100 m). The BM is inclined at low angle (4-6°) near the western margin of the fold. The overlying unit encompasses a heterogeneous stratigraphic sequence deposited, at least locally, on a high-relief erosional surface. The unit's basal sequence is a coarse-grained non-marine paleochannel fill. Interbedded silt and sand (tidal-flat and channel deposits and shallow-water marine) that frequently contains wood and charcoal characterize the upper sequence. The Lava Creek ash (~665 ka) is present in the lower part of the upper sequence. A middle-Pleistocene marine transgression truncated older deposits and beveled off the western "nose" of the fold. The broad abrasion platform has a minor inclination, but does not appear to be significantly tilted. The abrasion platform is overlain by sand that contains shallow water and intertidal marine mollusks with amino-acid ratios comparable to mollusks in the type Upper Bent Spring Chronozone (^{18}O stage 9 highstand, ~320 ka). The marine sequence transitions into an overall upward fining fluvial sequence locally capped by a paleosol that is, in turn, buried by late Pleistocene, and locally Holocene, fluvial sediments.

Our chronostratigraphic model indicates that growth of the northern shelf monocline continued into the early Pleistocene, but slowed significantly during middle Pleistocene time. Deformation virtually ceased by the ^{18}O stage 9 highstand, ~320 ka. The ^{18}O stage 9 highstand shoreline angle along the western margin of the northern shelf is at an elevation of 41-44 m, constraining vertical uplift to 0.13-0.14 mm/yr for the last ~320 ka. This rate of uplift is comparable to rates of uplift along other parts of the western U.S. thought to be a result of isostatic compensation or broad-scale regional uplift along the plate boundary. Recent structural interpretations using various fold models have provided long-term (Pliocene-Recent) vertical slip rate estimates of 0.26 to >1.3 mm/yr for blind thrust fault(s) thought to underlie the monocline. These rates are a factor of 2 to an order of magnitude greater than our data allow. We therefore suggest that rates of recent compressive fault activity in the northern Los Angeles basin are considerably slower than previously proposed and may have essentially ceased. We also caution the use of structural model derived long-term slip rates for blind-faults in present-day seismic hazard analysis.

Non-Technical Summary – This investigation models Quaternary deformation beneath the La Brea plain, which is located between the Los Angeles Civic Center, Beverly Hills, and Hollywood, California. This area is postulated to be undergoing uplift and folding by active "blind" faulting. Several contrasting geologic structural models have been proposed for this area that provide differing estimates of blind-fault geometry and activity. To evaluate these proposals, we developed a three-dimensional model of Quaternary deformation through a multi-disciplinary approach using existing subsurface information (boring logs) and samples. Our data indicate that uplift and folding beneath the present day La Brea plain was active in the early Pleistocene, however, activity slowed significantly in the middle Pleistocene, and deformation virtually ceased by 320,000 years ago. Previous interpretations of blind-fault activity based on long-term (Pliocene-Recent) rates of deformation are significantly greater than our data allow and overpredict late Quaternary activity. Therefore, caution should be applied when using long-term rates of deformation in present-day seismic hazard analysis. This study demonstrates that developing detailed Quaternary deformational histories can provide a powerful means of assessing the hazard potential of blind faults.